

What is claimed is:

1 1. An application execution apparatus comprising a
2 kernel unit and at least one library unit which provides
3 resources to applications,

4 wherein the kernel unit includes
5 notifying means for notifying, when an application
6 is completed, each library unit which has provided a
7 resource to the application, of the application, and

8 each library unit includes
9 collecting means for collecting the resource provided
10 to the application, upon receiving the notification from
11 the notifying means.

1 2. The application execution apparatus of Claim 1,
2 wherein the collecting means includes:

3 table holding means for holding a table which shows
4 a correspondence between applications and resources
5 provided to the applications; and

6 resource specifying means for specifying the resource
7 provided to the application notified by the notifying means,
8 based on the table in the table holding means.

1 3. The application execution apparatus of Claim 2,
2 wherein each library unit further includes:

3 providing means for providing the resource to the
4 application, in accordance with a request from the
5 application;

6 registering means for receiving from the kernel unit
7 a notification of the application provided with the
8 resource, and registering a correspondence of the
9 application and the resource into the table in the table
10 holding means; and

11 deleting means for deleting, when the collecting
12 means collects the resource provided to the application,
13 the correspondence of the application and the resource from
14 the table.

1 4. The application execution apparatus of Claim 1,
2 wherein each library unit further includes:

3 providing means for providing the resource to the
4 application, in accordance with a request from the
5 application; and

6 requesting means for requesting, when the providing
7 means first provides the resource to the application, the
8 notifying means to make the notification when the
9 application is completed.

1 5. The application execution apparatus of Claim 4,
2 wherein the requesting means requests the notifying
3 means to make the notification by calling a callback
4 function, and

5 the notifying means makes the notification by calling
6 and executing the callback function, when the application
7 is completed.

1 6. The application execution apparatus of Claim 1,
2 wherein the notifying means includes a plurality of
3 notifying units which each correspond to a different
4 application, and

5 each library unit further includes:

6 providing means for providing the resource to the
7 application, in accordance with a request from the
8 application; and

9 requesting means for requesting, when the providing
10 means first provides the resource to the application, a
11 notifying unit corresponding to the application to make
12 the notification when the application is completed.

1 7. The application execution apparatus of Claim 6,
2 wherein the requesting means requests the notifying
3 unit to make the notification by calling a method of a
4 resource collection instance, the resource collection
5 instance being generated by the library unit to receive
6 the notification, and

7 the notifying unit makes the notification by calling
8 the method of the resource collection instance, when the
9 application is completed.

1 8. The application execution apparatus of Claim 1,
2 wherein when at least two applications are completed
3 at the same time, the notifying means notifies each library

4 unit which has provided resources to the applications, of
5 the applications,

6 the collecting means includes:

7 table holding means for holding a table showing a
8 correspondence between applications and resources
9 provided to the applications; and

10 resource specifying means for specifying the
11 resources provided to the applications notified by the
12 notifying means, based on the table in the table holding
13 means, and

14 the collecting means collects the specified
15 resources.

1 9. The application execution apparatus of Claim 1,
2 wherein the resources include a tuner, an MPEG decoder,
3 a remote control, a file system, a memory, and a modem.

1 10. The application execution apparatus of Claim 9,
2 wherein the collecting means includes:

3 table holding means for holding a table which shows
4 a correspondence between applications and resources
5 provided to the applications; and

6 resource specifying means for specifying the resource
7 provided to the application notified by the notifying means,
8 based on the table in the table holding means.

1 11. The application execution apparatus of Claim 10,

2 wherein each library unit further includes:
3 providing means for providing the resource to the
4 application, in accordance with a request from the
5 application;
6 registering means for receiving from the kernel unit
7 a notification of the application provided with the
8 resource, and registering a correspondence of the
9 application and the resource into the table in the table
10 holding means; and
11 deleting means for deleting, when the collecting
12 means collects the resource provided to the application,
13 the correspondence of the application and the resource from
14 the table.

1 12. The application execution apparatus of Claim 9,
2 wherein each library unit further includes:
3 providing means for providing the resource to the
4 application, in accordance with a request from the
5 application; and
6 requesting means for requesting, when the providing
7 means first provides the resource to the application, the
8 notifying means to make the notification when the
9 application is completed.

1 13. The application execution apparatus of Claim 12,
2 wherein the requesting means requests the notifying
3 means to make the notification by calling a callback

4 function, and

5 the notifying means makes the notification by calling
6 and executing the callback function, when the application
7 is completed.

1 14. The application execution apparatus of Claim 9,
2 wherein the notifying means includes a plurality of
3 notifying units which each correspond to a different
4 application, and

5 each library unit further includes:

6 providing means for providing the resource to the
7 application, in accordance with a request from the
8 application; and

9 requesting means for requesting, when the providing
10 means first provides the resource to the application, a
11 notifying unit corresponding to the application to make
12 the notification when the application is completed.

1 15. The application execution apparatus of Claim 14,
2 wherein the requesting means requests the notifying
3 unit to make the notification by calling a method of a
4 resource collection instance, the resource collection
5 instance being generated by the library unit to receive
6 the notification, and

7 the notifying unit makes the notification by calling
8 the method of the resource collection instance, when the
9 application is completed.

1 16. The application execution apparatus of Claim 9,
2 wherein when at least two applications are completed
3 at the same time, the notifying means notifies each library
4 unit which has provided resources to the applications, of
5 the applications,

6 the collecting means includes:

7 table holding means for holding a table showing a
8 correspondence between applications and resources
9 provided to the applications; and

10 resource specifying means for specifying the
11 resources provided to the applications notified by the
12 notifying means, based on the table in the table holding
13 means, and

14 the collecting means collects the specified
15 resources.

1 17. The application execution apparatus of Claim 1,
2 wherein the notifying means makes the notification
3 when the application is completed or suspended,

4 each library unit further includes

5 judging means for judging whether the resource
6 provided to the application should be collected, depending
7 on whether the application has been completed or suspended,
8 and

9 the collecting means collects the resource provided
10 to the application, when the judging means judges that the

11 resource should be collected.

1 18. The application execution apparatus of Claim 17,
2 wherein the notifying means includes a plurality of
3 notifying units which each correspond to a different
4 application, and

5 each library unit further includes:

6 providing means for providing the resource to the
7 application, in accordance with a request from the
8 application; and

9 requesting means for requesting, when the providing
10 means first provides the resource to the application, a
11 notifying unit corresponding to the application to make
12 the notification when the application is completed or
13 suspended.

1 19. The application execution apparatus of Claim 18,
2 wherein the requesting means requests the notifying
3 unit to make the notification by calling a method of a
4 resource collection instance, the resource collection
5 instance being generated by the library unit to receive
6 the notification,

7 the notifying unit makes the notification by calling
8 the method of the resource collection instance, when the
9 application is completed or suspended, and

10 the judging means (a) receives the notification, (b)
11 acquires information showing whether the application has

12 been completed or suspended, and (c) judges whether the
13 resource should be collected, depending on the acquired
14 information.

1 20. An application execution apparatus comprising a
2 Java middleware unit and an OS (Operating System) unit which
3 provides resources to applications,

4 wherein the Java middleware unit includes:

5 first table holding means for holding a table which
6 shows a correspondence between applications, tasks
7 corresponding to the applications, and threads which make
8 up each task; and

9 notifying means for notifying, upon receiving an
10 instruction to complete an application, the OS unit of a
11 task corresponding the application, based on the table in
12 the first table holding means, and

13 the OS unit includes:

14 task generating means for generating the task for
15 executing the application;

16 thread generating means for generating application
17 threads which make up the task generated by the task
18 generating means;

19 controlling means for executing the generated
20 application threads to execute program codes of the
21 application, providing resources to the application in
22 accordance with a request from the application, and
23 registering a correspondence between the provided

24 resources and the task to which the application threads
25 belong, into a table showing a correspondence between
26 provided resources and tasks corresponding to
27 applications; and

28 collecting means for specifying the resources
29 corresponding to the task notified by the notifying means
30 based on the table in the controlling means, and collecting
31 the specified resources.

1 21. The application execution apparatus of Claim 20,
2 wherein the Java middleware unit further includes:
3 requesting means for requesting to notify the
4 application which is being executed, of a change of a status
5 of a device; and
6 status change notifying means for notifying the
7 application of the change, upon detecting the change.

1 22. The application execution apparatus of Claim 21,
2 wherein the requesting means requests the status
3 change notifying means to call a listener which waits to
4 be informed of the change, and
5 the status change notifying means makes the
6 notification by calling the listener, upon detecting the
7 change.

1 23. The application execution apparatus of Claim 22,
2 wherein the status change notifying means generates

3 a special thread for calling the listener, and calls the
4 listener by executing the special thread,

5 the Java middleware unit further includes:

6 second table holding means for holding a table showing
7 a correspondence between listeners, special threads, and
8 applications; and

9 table renewing means for referencing the table in the
10 second table holding means when the requesting means
11 requests the status change notifying means to call the
12 listener, judging whether the application corresponding
13 to the listener is shown in the table, and adding the
14 listener to the table in correspondence with the
15 application if the application is shown in the table, and

16 the status change notifying means does not generate
17 the special thread if the table renewing means judges that
18 the application is shown in the table, and generates the
19 special thread if the table renewing means judges that the
20 application is not shown in the table.

1 24. The application execution apparatus of Claim 23,
2 wherein the special thread monitors whether
3 information showing the occurrence of the change is held
4 in a queue which transfers information between threads,
5 and calls the listener upon detecting that the information
6 is held in the queue.

1 25. The application execution apparatus of Claim 23,

2 wherein the special thread is in a wait state before
3 information showing the occurrence of the change is held
4 in a queue which transfers information between threads,
5 and becomes active and calls the listener when the
6 information is held in the queue.

1 26. The application execution apparatus of Claim 20,
2 wherein the Java middleware unit further includes:
3 resource reserve thread generating means for
4 generating a resource reserve thread for reserving
5 resources necessary for the Java middleware unit; and
6 resource reserving means for reserving the resources
7 necessary for the Java middleware unit, by executing the
8 resource reserve thread, and
9 the collecting means specifies the resources
10 corresponding to the notified task based on the table in
11 the controlling means, and collects the specified
12 resources, without collecting the resources reserved by
13 the resource reserving means.

1 27. An application execution apparatus comprising a
2 middleware unit and an OS unit which provides resources
3 to applications,
4 wherein the middleware unit includes
5 notifying means for (a) notifying the OS unit of an
6 application which requests resources, in accordance with
7 a request from the OS unit, and (b) notifying the OS unit

8 of the application when the application is completed, and
9 the OS unit includes:

10 requesting means for requesting the notifying means
11 to notify of the application which requests the resources;
12 resource management table holding means for holding
13 a table showing a correspondence between applications
14 notified by the notifying means and resource names of
15 provided resources; and

16 resource collecting means for specifying, when
17 notified by the notifying means of the application which
18 is completed, the resources corresponding to the notified
19 application based on the table in the resource management
20 table holding means, and collecting the specified
21 resources.

1 28. The application execution apparatus of Claim 27,
2 wherein the notifying means includes:

3 loader specifying means for specifying a class loader
4 that loaded the application which requests the resources;
5 table holding means for holding a table showing a
6 correspondence between loaded applications and class
7 loaders which loaded the applications; and

8 application specifying means for specifying the
9 application corresponding to the specified class loader,
10 based on the table in the table holding means.

1 29. The application execution apparatus of Claim 28,

2 wherein the loader specifying means specifies the
3 class loader, by referencing a stack which stores
4 information on a caller of a class of the application.

1 30. The application execution apparatus of Claim 29,
2 wherein the OS unit further includes
3 assigning means for assigning an application ID to
4 each application, and

5 the notifying means notifies the OS unit of the
6 application which requests the resource by notifying the
7 OS unit of an application ID of the application, and
8 notifies the OS unit of the application which is completed
9 by notifying the OS unit of the application ID of the
10 application.

1 31. The application execution apparatus of Claim 28,
2 wherein the OS unit further includes
3 assigning means for assigning an application ID to
4 each application, and

5 the notifying means notifies the OS unit of the
6 application which requests the resource by notifying the
7 OS unit of an application ID of the application, and
8 notifies the OS unit of the application which is completed
9 by notifying the OS unit of the application ID of the
10 application.

1 32. The application execution apparatus of Claim 27,

2 wherein the OS unit further includes
3 assigning means for assigning an application ID to
4 each application, and
5 the notifying means notifies the OS unit of the
6 application which requests the resource by notifying the
7 OS unit of an application ID of the application, and
8 notifies the OS unit of the application which is completed
9 by notifying the OS unit of the application ID of the
10 application.

1 33. A computer-readable recording medium recording
2 a program for use in an application execution apparatus
3 equipped with a kernel unit and a plurality of library units
4 which provide resources to applications, the program
5 comprising:

6 a notifying step in the kernel unit for notifying,
7 when an application is completed, each library unit which
8 has provided a resource to the application, of the
9 application; and

10 a collecting step in each library unit for collecting
11 the resource provided to the application, upon receiving
12 the notification.

1 34. The computer-readable recording medium of Claim
2 33,

3 wherein the notifying step makes the notification
4 when the application is completed or suspended,

5 the program further comprises
6 a judging step in each library unit for judging whether
7 the resource provided to the application should be
8 collected, depending on whether the application has been
9 completed or suspended, and
10 the collecting step collects the resource provided
11 to the application, when the judging step judges that the
12 resource should be collected.

1 35. A computer-readable recording medium recording
2 a program for use in an application execution apparatus
3 equipped with a Java middleware unit and an OS unit which
4 provides resources to applications, the Java middleware
5 unit including a first table holding unit for holding a
6 table which shows a correspondence between applications,
7 tasks corresponding to the applications, and threads which
8 make up each task, the program comprising:

9 a notifying step in the Java middleware unit for
10 notifying, upon receiving an instruction to complete an
11 application, the OS unit of a task corresponding the
12 application, based on the table in the first table holding
13 unit;

14 a task generating step in the OS unit for generating
15 the task for executing the application;

16 a thread generating step in the OS unit for generating
17 application threads which make up the task generated in
18 the task generating step;

19 a controlling step in the OS unit for executing the
20 generated application threads to execute program codes of
21 the application, providing resources to the application
22 in accordance with a request from the application, and
23 registering a correspondence between the provided
24 resources and the task to which the application threads
25 belong, into a table showing a correspondence between
26 provided resources and tasks corresponding to
27 applications; and

28 a collecting step in the OS unit for specifying the
29 resources corresponding to the task notified by the
30 notifying step based on the table, and collecting the
31 specified resources.

1 36. A computer-readable recording medium recording
2 a program for use in an application execution apparatus
3 equipped with a middleware unit and an OS unit which
4 provides resources to applications, the OS unit including
5 a resource management table holding unit for holding a table
6 showing a correspondence between applications and resource
7 names of resources provided to the applications, the
8 program comprising:

9 a notifying step in the middleware unit for (a)
10 notifying the OS unit of an application which requests
11 resources, in accordance with a request from the OS unit,
12 and (b) notifying the OS unit of the application when the
13 application is completed;

14 a requesting step in the OS unit for requesting the
15 middleware unit to notify of the application which requests
16 the resources; and

17 a resource collecting step in the OS unit for
18 specifying, when notified by the notifying step of the
19 application which is completed, the resources
20 corresponding to the notified application based on the
21 table in the resource management table holding unit, and
22 collecting the specified resources.

37. An application execution apparatus for managing
a memory heap area for applications which requires garbage
collection, comprising:

divided heap area acquiring means for acquiring a
divided heap area in the memory heap area, when an
application is started;

allocating means for allocating the divided heap area
acquired by the divided heap area acquiring means, to the
application; and

memory releasing means for releasing the divided heap
area allocated to the application, when the application
is completed.

38. The application execution apparatus of Claim 37,
further comprising:

object area acquiring means for acquiring an object
area in the divided heap area, for an object relating to

5 the application; and
6 garbage collecting means for performing garbage
7 collection on the divided heap area.

1 39. The application execution apparatus of Claim 38,
2 further comprising
3 locking means for suspending the execution of the
4 application while the garbage collecting means is
5 performing the garbage collection on the divided heap area.

1 40. The application execution apparatus of Claim 37,
2 further comprising
3 table holding means for holding a table showing a
4 correspondence between applications being executed and
5 divided heap areas allocated to the applications, and
6 the memory releasing means specifies the divided heap
7 area corresponding to the completed application based on
8 the table in the table holding means, and releases the
9 divided heap area.

1 41. The application execution apparatus of Claim 37,
2 further comprising
3 table holding means for holding a table showing a
4 correspondence between applications being executed and
5 divided heap areas allocated to the applications, and
6 when the application is started, the allocating means
7 registers a correspondence of the application and the

8 divided heap area allocated to the application, in the table
9 in the table holding means.

1 42. An application execution apparatus for managing
2 a memory heap area for applications which requires garbage
3 collection, comprising:

4 system heap area allocating means for allocating the
5 memory heap area as a system heap area;

6 object area acquiring means for acquiring a
7 system-related object area in the system heap area;

8 divided heap area acquiring means for acquiring a
9 divided heap area in the system heap area, when an
10 application is started;

11 allocating means for allocating the divided heap area
12 to the application; and

13 memory releasing means for releasing the divided heap
14 area allocated to the application, when the application
15 is completed.

1 43. The application execution apparatus of Claim 42,
2 further comprising

3 garbage collecting means for performing garbage
4 collection on the system heap area in units of divided heap
5 areas.

1 44. A memory heap management method used in an
2 apparatus for managing a memory heap area for applications

3 which requires garbage collection, comprising:
4 a divided heap area acquiring step for acquiring a
5 divided heap area in the memory heap area, when an
6 application is started;
7 an allocating step for allocating the divided heap
8 area acquired by the divided heap area acquiring step, to
9 the application; and
10 a memory releasing step for releasing the divided heap
11 area allocated to the application, when the application
12 is completed.

1 45. The memory heap management method of Claim 44,
2 further comprising:
3 an object area acquiring step for acquiring an object
4 area in the divided heap area, for an object relating to
5 the application; and
6 a garbage collecting step for performing garbage
7 collection on the divided heap area.

1 46. The memory heap management method of Claim 45,
2 further comprising
3 a locking step for suspending the execution of the
4 application while the garbage collecting step is
5 performing the garbage collection on the divided heap area .

1 47. The memory heap management method of Claim 44,
2 wherein the apparatus includes a table holding unit

3 for holding a table showing a correspondence between
4 applications being executed and divided heap areas
5 allocated to the applications, and
6 the memory releasing step specifies the divided heap
7 area corresponding to the completed application based on
8 the table in the table holding unit, and releases the
9 divided heap area.

1 48. The memory heap management method of Claim 44,
2 wherein the apparatus includes a table holding unit
3 for holding a table showing a correspondence between
4 applications being executed and divided heap areas
5 allocated to the applications, and
6 when the application is started, the allocating step
7 registers a correspondence of the application and the
8 divided heap area allocated to the application, in the table
9 in the table holding unit.

1 49. A memory heap management method for managing a
2 memory heap area for applications which requires garbage
3 collection, comprising:

4 a system heap area allocating step for allocating the
5 memory heap area as a system heap area;

6 an object area acquiring step for acquiring a
7 system-related object area in the system heap area;

8 a divided heap area acquiring step for acquiring a
9 divided heap area in the system heap area, when an

10 application is started;
11 an allocating step for allocating the divided heap
12 area to the application; and
13 a memory releasing step for releasing the divided heap
14 area allocated to the application, when the application
15 is completed.

1 50. The memory heap management method of Claim 49,
2 further comprising
3 a garbage collecting step for performing garbage
4 collection on the system heap area in units of divided heap
5 areas.

1 51. A computer-readable recording medium recording
2 a program for use in an apparatus that executes applications
3 using a memory heap area which requires garbage collection,
4 the program comprising:

5 a divided heap area acquiring step for acquiring a
6 divided heap area in the memory heap area, when an
7 application is started;

8 an allocating step for allocating the divided heap
9 area acquired by the divided heap area acquiring step, to
10 the application; and

11 a memory releasing step for releasing the divided heap
12 area allocated to the application, when the application
13 is completed.

1 52. The computer-readable recording medium of Claim
2 51, the program further comprising:
3 an object area acquiring step for acquiring an object
4 area in the divided heap area, for an object relating to
5 the application; and
6 a garbage collecting step for performing garbage
7 collection on the divided heap area.

1 53. The computer-readable recording medium of Claim
2 52, the program further comprising
3 a locking step for suspending the execution of the
4 application while the garbage collecting step is
5 performing the garbage collection on the divided heap area.

1 54. The computer-readable recording medium of Claim
2 51
3 wherein the apparatus includes a table holding unit
4 for holding a table showing a correspondence between
5 applications being executed and divided heap areas
6 allocated to the applications, and
7 the memory releasing step specifies the divided heap
8 area corresponding to the completed application based on
9 the table in the table holding unit, and releases the
10 divided heap area.

1 55. The computer-readable recording medium of Claim
2 51,

3 wherein the apparatus includes a table holding unit
4 for holding a table showing a correspondence between
5 applications being executed and divided heap areas
6 allocated to the applications, and
7 when the application is started, the allocating step
8 registers a correspondence of the application and the
9 divided heap area allocated to the application, in the table
10 in the table holding unit.

1 56. A computer-readable recording medium recording
2 a program for use in an apparatus that executes applications
3 using a memory heap area which requires garbage collection,
4 the program comprising:

5 a system heap area allocating step for allocating the
6 memory heap area as a system heap area;

7 an object area acquiring step for acquiring a
8 system-related object area in the system heap area;

9 a divided heap area acquiring step for acquiring a
10 divided heap area in the system heap area, when an
11 application is started;

12 an allocating step for allocating the divided heap
13 area to the application; and

14 a memory releasing step for releasing the divided heap
15 area allocated to the application, when the application
16 is completed.

1 57. The computer-readable recording medium of Claim

2 56, the program further comprising
3 a garbage collecting step for performing garbage
4 collection on the system heap area in units of divided heap
5 areas.